RESEARCH IN STUDENT PERFORMANCE

Student Performance Assessment Research and It's Application to Curriculum Development

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Abstract

This presentation will briefly describe a current statistical study and student performance assessment methodologies that are under development at Alabama A&M University. The presentation will focus on two research objectives: (1) Develop a set of statistical models that will connect university curriculum variables to outputs such as student performance in a particular mathematics class or on post-graduate standardized examinations. (2) Use statistical models to assess the performance effectiveness of a variety of teaching and tutoring methodologies. A brief description of activities and technology infrastructure that supports objectives 1 and 2 are provided. Specific example applications of the proposed statistical model and mathematics course exit-tests will be presented. Closing comments will be related to how the above, NASA supported, research provides a statistical infrastructure which may be used to make decisions regarding curriculum adjustments.

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The author of this paper spent summers of 1994-95 as a National Aeronautics and Space Administration (NASA) Summer Faculty Research Fellow. While in this program, he researched statistical methodologies that may be used to enhance the flaw detection performance of space-age nondestructive evaluation (NDE) equipment. Flaw detection performance research naturally led to a study of statistical models which may be used to classify the type of flaws detected. Flaw detection and classification are important because they provide information that may be used by an engineer to predict the life and reliability of a system in which a flaw has (or has not) been detected. Statistical tools such as regression discriminant analysis and neural network analysis were applied in the model construction process.

In the fall of 1997, NASA awarded the Mathematics Department of Alabama A&M University (AAMU) a grant which is being used to apply modeling technology in an educational setting.

Specifically, the type of statistical models used to study NDE equipment performance is being applied to model student performance. Strategies used to maximize performance in both systems are similar. Hence, the main focus of this research is to apply the above mentioned statistical tools to enhance AAMU's student performance in science and engineering. The enhancement process includes (1) the detection of student deficiencies (diagnosis), (2) classification (placement) and (3) curriculum adjustments (experimentation). The four major objectives of this research are (1) to identify a set of control and noise variables that are most likely to influence student performance, (2) to define a set of models that connect student performance to control and noise variables, (3) to determine how all variables and their interactions influence performance, (4) to identify the setting for variables that will maximize student performance.

Section 3 will discuss the need for this type of research and section 2 briefly describes the statistical model and gives an example. Computer equipment used for data collection and testing in described in section 4 and section 5 mentions benefits and recommendations.

A General Model

This section contains a few equations which may not be of interest to the general audience for this publication. However, the equations serve to identify what is meant by input and output variables and how I plan to connect them. For a simple variable connection equation, readers may wish to restrict their focus to equation (2.1).

Assume that y is the output of a student evaluation system (say, a course exit test) with a normal probability distribution of mean μ. Further assume that input (control) variables $x_1,x_2 \ldots ,x_k$ and noncontrollable noise variables $z_1,z_2,\ldots ,z_m$ have influence on output y. For compactness, let control vector $\underline{x} = (x_1,x_2,\ldots,x_k)'$ and noise vector $\underline{Z} = (z_1,z_2,\ldots,z_m)$. A general equation that connects output y to $\underline{x}$ and $\underline{z}$ is

$$Y = \beta_0 + \underline{X}' \underline{\beta} + \underline{Z}' \underline{\delta} + \underline{X}' \Lambda \underline{Z} + \varepsilon \qquad (2.1)$$

where $\underline{\beta}$ is a general parameter of vector coefficients of control variables, $\underline{\delta}$ is a coefficient vector of noise variables, Λ is a matrix which contains the coefficients of the interactions between noise and control variables, and ε is a random lack of fit component.

Model system (2.1) generates two response surfaces that are of benefit to student performance evaluation. They are system output mean which is given by

$$E[y] = \mu = \beta_0 + \underline{x}' \underline{\beta} \qquad (2.2)$$

and system output variance

$$Var[y] = \sigma^2 = [\underline{\delta} + \underline{X}' \underline{V}] V [\underline{\delta} + \underline{X}' \Lambda]', \qquad (2.3)$$

where V is the variance-covariance matrix for noise variables in $\underline{Z}$. Observed data on y, $\underline{X}$, and $\underline{Z}$ may be used to estimate parameter values β_0, $\underline{\beta}$, $\underline{\delta}$, and Λ. Once the parameters are estimated and substituted into equation (2.1), the model is ready to be used. The reader should be reminded that a single model may have several uses: (1) prediction of output variable when inputs are known, (2) adjustment of input variables so that some desired control is imposed on the output, (3) hypotheses testing. At various stages in this research I will use all of the above applications.

Need for Research and an Application

Need for Research

In an effort to assist government agencies, major universities, and historically black colleges and universities (HBCU) in their decision making process regarding the strengthening of HBCU's, several studies have been done. For example, Brazziel and Brazziel (1994), in an extensive data analysis project, evaluated the influence of educational and demographic variables on the graduation rate of minority doctorates in science and engineering Program. Solorzano (1995) examines the baccalaureate origin of African-Americans who earned doctorates during the 1980-1990 time period. Rotberg (1990) studied trends in financial support and institutional priorities with respect to minority participation in science and engineering programs. All of these studies have been very useful. However, I have been unable to locate a comprehensive study of the effectiveness of science and engineering programs at an HBCU. No study at any HBCU has developed a statistical model that connects university environmental and academic variables to student performance on, say, the GRE or other post graduate examinations. Models of this type are unique to a particular university. Therefore, the absence of such HBCU studies, combined with recent emphasis on college student performance assessment by funding and accreditation agencies, as left some HBCU faculty and administrators uncertain about what to assess and how to use assessment results. This research will develop a set of models that will connect input variables on academic background, university curricula and university environment to various measurements for academic output. A single example of academic output is given in the next paragraph.

An Application at AAMU (Now under development because data collection process requires four years.)

Let us suppose that the output variable is a student's on the GRE or one of its subtests. The input variables may be GPA, scores on standard exit-examinations for mathematics courses, practice GRE tests administed at various periods during the student's under graduate study, academic class load, tutoring for GRE, etc. Once the model is developed, the GRE score may be predicted at, say, the sophomore level of study. If the predicted score does not meet desired level, student is counseled with regard to specific adjustments that must be made within the next two years to achieve a desired score.

Technology Infrastructure and Other Activities

Computer Support

During the 1997-98 academic year, the computer committee of the AAMU Mathematics Department provided several significant enhancements to the departmental computer facilities. This includes configuring faculty computers to interface with an NT server, installation of MAPLE V, EXP, Internet Explorer, etc. All of these enhancements improved student and faculty accesses to the math lab network.

Software for Testing and Research

We have recently acquired a computer adaptive testing package (COMPASS) and a statistical computer package (SAS). We have also acquired the Gateway Computer Administered Calculus tests, which are marketed by the Wiley Book Company. We will use the Wiley tests as calculus exit-tests for calculus I, II and III. A commercially provided computer adaptive GRE package from the ETS company has been installed. Data collected by COMPASS, the Wiley tests and the GRE package will be merged and uploaded into SAS where statistical analyses will be performed.

GRE Requirement for Graduation

As specified on page 174 of the 1998 AAMU undergraduate bulletin, all seniors who are enrolled in the School of Arts and Sciences must take the GRE before they graduate. The advantage of this requirement has been discussed with the School of Engineering administration and they are now considering the GRE requirement.

Testing

An extensive review of commercially available tests for research purposes has been conducted. These reviews combined with our technology infrastructure described in this section influenced us to adopt computer administrated placement/exit exams for college algebra through calculus III. Computer tests were administered to a sample of 350 algebra and calculus students in August 1998. Exit-tests were administered to this sample at the end of Fall semester, 1998. Data summary analyses are in progress.

Benefits

This research project has already provided a statistical infrastructure upon which the effectiveness of old and new curriculum programs may be evaluated. The decision process of curriculum personnel, administrators and researchers in science and education have already been influenced by its results. For example, the Computer Science Program recently submitted a $1.5 million proposal to NSF. It used data collected by this project and the evaluation segment of that proposal is heavily based on models being developed by this research.

MU-SPIN

The poster presentation at The 1999 MU-SPIN Ninth Annual User's Conference shows descriptive statistics through charts and graphs that have been collected by this project.

References

Brazziel, W.F. and M.E. Brazziel. (1993). New sources for minority doctoral starts. Journal of Negro Education, 147-152.

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Solorzano, D.G. (1995). Doctorate production and baccalaureate origins of African-americans. Journal of Negro Education, 15-32.